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3. Using mixed logit models to derive individual-specific WTP estimates for landscape improvements under agri-environmental schemes: evidence from the Rural Environment Protection Scheme in Ireland

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INTRODUCTION

After more than fifty years of European Union (EU) agricultural policies designed to support farm incomes through farm commodity prices, there has been a significant shift in emphasis. With an increased focus on area-based payments and payments for the supply of environmental goods, agri-environmental schemes have become an important component within the Common Agricultural Policy (CAP), as also discussed in Chapters 4, 5 and 6 of this volume. Within this context, the Rural Environment Protection (REP) Scheme was introduced in the Republic of Ireland in 1994. Designed to pay farmers for carrying out their farming activities in an environmentally friendly manner, the Scheme is aimed at creating incentives for farmers to maintain and improve the broadly defined rural environment and the rural landscape.

By the end of 2004, over €1.5 billion had been paid to Irish farmers under the REP Scheme. Assessing whether the Scheme has offered value for money requires an examination of both its costs and benefits. While the financial costs are readily available, calculating the benefits is more problematic. Aside from the financial benefits farmers derive from participation, the REP Scheme offers a range of benefits to society (Gorman *et al*., 2001; Mannion *et al*., 2001). Some of these are the enhanced value of rural landscape aesthetics, recreation amenities, improved water quality, wildlife preservation and the maintenance of historical and archaeological features. Moreover, since no studies have sought to estimate these benefits, very little is known about their extent and magnitude (DAF, 1999). A monetary valuation of an Environmentally Sensitive Area Scheme in Northern Ireland was conducted by Moss and Chilton (1997) and a number of studies in other countries have examined the non-market benefits of agri-environmental schemes (for a review see Stewart *et al*., 1997). Differences in the schemes and population characteristics, however, mean these estimates can only provide an approximation of the non-market benefits of the REP Scheme. Agri-environmental policy in Ireland is also of interest in that it is unique in the EU in the combination of its comprehensiveness and its being available to all farmers throughout the country (Emerson and Gillmor, 1999). With this in mind, a key objective of this study was to quantify some of the non-market benefits arising from such a comprehensive and universal policy.

Landscape conservation and improvement is currently one of the priorities of the revised CAP and the vision of a multifunctional agriculture it intends to promote (Randall, 2002). The policy measures of the REP Scheme contribute to various rural landscape attributes, and hence a multi-attribute valuation approach is warranted. At the same time the public good and non-market nature of rural landscapes favour the use of a stated preference methodology. Reported in this chapter are the results from two discrete choice experiments that were carried out to address the public's willingness to pay (WTP) for the major farm landscape improvement measures within the REP Scheme in Ireland.

Using a mixed logit specification which accounts for unobserved taste heterogeneity, this chapter derives WTP distributions for each of the main landscape attributes improved by the scheme based on parameter estimates obtained from the individual conditional distributions. Since benefits estimates for strict improvements impose conceptual lower bounds on values which may be estimated in different ways, the occurrence of negative values in inference must therefore be excluded by making adequate assumptions in model specification and estimation (Train and Weeks, 2005). In this chapter, estimates are bound such that they are strictly positive while allowing for preference variation within the sample, using an approach proposed by Hensher and Greene (2003). Individual-specific estimates from all attributes are subsequently adjusted and combined to account for baselines and levels of improvement resulting from the implementation of the REP Scheme. Individual-specific WTP estimates are thus obtained for the contribution of the Scheme to rural landscapes. This result is subsequently contrasted with the average cost of the Scheme across the Irish adult population. Results indicate that the REP Scheme contributes substantial benefits to rural landscapes.

The remainder of the chapter is organised as follows. The next two sections provide a brief background on the REP Scheme and an outline of the design of the experiment, including the attributes, experimental design and consistency tests respectively. The subsequent section specifies and explains the mixed logit model used to obtain individual-specific WTP estimates for each of the landscape attributes. The fifth section reports and discusses the relevant results from the analysis and details the approach used to calibrate the individual-specific WTP estimates derived from the mixed logit model. The final section draws some conclusions and policy implications.

THE REP SCHEME

The reform of the CAP has addressed environmental concerns by promoting environmentally friendly farming since 1992. Council Regulation 2078/92 promoted farmers to the roles of managers, stewards and custodians of the rural environment alongside that of food commodity producers. For the first time Member States were required to establish region-specific agri-environmental schemes. Against this backdrop, in 1994 Ireland developed the REP Scheme with the stated objectives (DAF, 2004c) of:

- establishing farming practices and production methods which reflect the increasing concern for conservation, landscape protection and wider environmental problems.
- protecting wildlife habitats and endangered species of flora and fauna.
- producing quality food in an extensive and environmentally friendly manner.

The overall intention of the REP Scheme is to make support payments to farmers conditional on their implementing good and/or environment-friendly farming practice. The Scheme is about paying farmers to provide public goods in the form of environmental services (Hamell, 2001), on the assumption that opportunity costs are being incurred in order to farm in an environment friendly manner.

By the end of 2004, about a third of all farms and agricultural land in Ireland was involved in the Scheme, which is voluntary and available universally, rather than being restricted to specific areas of the country. However, to qualify farmers must be farming at least three hectares of land and undertake to implement the Scheme on all of the holding and to farm it according to an individual comprehensive agri-environmental plan for five years. Farmers in the Scheme must undertake eleven basic measures, which are directed towards controlling nitrogen use and stocking rates, controlling waste and effluent around the farmyard and protecting water quality, hedgerows, stonewalls and features of archaeological or historical importance on their farm. They must also choose two biodiversity undertakings. In addition to the basic premium, extra payments are available to farmers who undertake supplementary measures.

SURVEY DESIGN

Attributes Used in the Choice Experiments

The discrete choice experiment exercises reported here involved several rounds of design and testing. This process began with a qualitative review of opinions from the policy administrators. Having identified the policy-relevant attributes, further qualitative research was carried out to refine the definitions of these attributes so they could be used in the survey. This was achieved through a series of focus group discussions, with members of the public. To ensure a geographical spread and to enable the identification of potentially different perspectives, four focus groups were conducted around Ireland. Following the focus group discussions, pilot testing of the survey instrument was conducted in the field. This allowed the collection of additional information, which along with expert judgement and observations from the focus group discussions, was used to identify and refine the landscape attributes and their levels. In the final version of the survey a total of eight important landscape attributes were identified: Wildlife Habitats, Rivers and Lakes, Hedgerows, Pastures, Mountain Land, Stonewalls, Farmyard Tidiness and Cultural Heritage.

Three levels were used to depict each landscape attribute according to the level of action made to conserve or enhance it. To minimise respondent confusion the levels for each landscape attribute were denoted using the same labels: A Lot Of Action, Some Action and No Action. While the A Lot Of Action and Some Action levels represented a high level and an intermediate level of improvement achievable within the REP Scheme respectively, the No Action level represented the unimproved or status quo condition. Image manipulation software was used to prepare photo-realistic simulations representing the landscape attributes under different management practices and levels of agricultural intensity. This involved the manipulation of a 'control' photograph to depict either more of or less of the attribute in question. This method was used so that on the one hand the changes in the attribute levels could be easily identified while holding other features of the landscape constant. On the other hand the respondent would not perceive as ostensibly unrealistic the computer-generated landscape illustrations. The Wildlife Habitats attribute depicted a field with different degrees of biodiversity. A range of levels of green cover on lake water reflecting eutrophication levels were used to represent the Rivers and Lakes attribute. The Hedgerows attribute was shown under different management practices. Different stocking densities in lowland and upland areas were used to depict the Pastures and Mountain Land attributes respectively. The Stonewalls attribute illustrated the consequence that their condition and absence has on the appearance of the countryside. Similarly, the Farmyard Tidiness attribute portrayed a farmyard at different levels of tidiness and the Cultural Heritage attribute showed the impact that different management practices have on old farm buildings and historical features. All images and accompanying text were tested in the focus group discussions and pilot study to ensure a satisfactory understanding and scenario acceptance by respondents.

The cost attribute was described as the Expected Annual Cost of implementing the alternatives represented in the choice questions. This attribute was specified as the value that the respondent would personally have to pay per year, through their Income Tax and Value Added Tax contributions, to implement the alternative. These are realistic payment vehicles for EU-funded and government-funded agricultural policies. As discussed later in more detail, the experimental design was sequential to allow for Bayesian learning (Ferrini and Scarpa, 2007) and the survey was administered in three phases, plus a pilot. This enabled the levels of the monetary attribute to be adjusted in response to the preliminary findings following each phase of the survey. Altogether seven price levels, ranging from €15 to €80, were used to represent the Expected Annual Cost attribute. The price levels that were used in each phase of the survey are shown in Table 3.1.

Table 3.1 Expected annual cost attribute price levels used during each phase of the survey

	€15	**€20**	**€35**	**€40**	**€50**	**€65**	**€80**
Phase 1		✓	✓		✓	✓	✓
Phase 2		✓					✓
Phase 3	✓	✓		✓	✓		

Sampling Method

In order to achieve a spatially representative sample, the sampling approach for the survey was firstly stratified according to 15 broad regions and five different community types (county boroughs; towns 10 000+ ; towns 5000 – 10 000; towns 1500 – 5000; and rural less than 1500) within the four standard areas of Dublin, Rest of Leinster, Munster and Connaught/Ulster. This approach was to ensure that all data generated could be analysed by the Nomenclature of Territorial Units for Statistics (NUTS) II and III regions, in addition to a range of urban and rural classifications. Within each of these broad regions, the appropriate number of primary sampling units, that is Electoral Divisions (EDs), was chosen. In total 100 EDs were selected.

The second stage of the sampling procedure involved the systematic sampling of six individuals within each of the pre-selected EDs. At each ED, the interviewer adhered to a quota control matrix based upon the known profile of Irish adults in the NUTS II regions in terms of age within sex, and socio-economic status. Within each ED, the nucleus of each cluster of interviews was an address selected on a probability basis from the 2003 Register of Electors. In order to limit interviewer bias the interviewers followed a random route procedure (for example first left, next right and so on) calling at every fifth house to complete an interview, until their controls were fulfilled.

The Discrete Choice Experiments

The central objective of the public survey was to elicit WTP estimates for the eight landscape attributes. Evidence from the focus group discussions revealed that respondents had difficultly evaluating choice tasks with more than five attributes. To circumvent this, the survey contained two separate choice experiments, each comprised of four randomly assigned landscape attributes and a cost attribute. Crucially, this enabled WTP estimates to be obtained for the eight rural landscape attributes for all respondents. The attributes used in each choice experiment are listed in Table 3.2. To avoid any biases that might exist due to the ordering of the two choice experiments, two versions of each questionnaire were developed, each version with a different sequence of presentation to the respondent of the two sets of choice tasks.

In each choice experiment respondents were asked to indicate their preferred alternative in a panel of repeated choice sets. Each choice set consisted of two experimentally designed alternatives, labelled Option A and Option B, and a status quo alternative, labelled No Action, which portrayed all the landscape attributes at the No Action level with zero cost to

Table 3.2 Landscape attributes used in each choice experiment

Choice experiment A	Choice experiment B
Wildlife Habitats	Mountain Land
Rivers and Lakes	Stonewalls
Hedgerows	Farmyard Tidiness
Pastures	Cultural Heritage

the respondent. Before both choice experiments, respondents were initially acquainted with the four landscape attributes used during the succeeding choice experiment. This was achieved by providing a show card for each of these attributes and allowing respondents time to examine them. When respondents had fully familiarised themselves with these attributes they were shown a sample 'rehearsal' choice set with three alternatives and were told that it represented rural environmental policy options open to the Government. An example of the choice sets used in choice experiments A and B are presented in Figures 3.1 and 3.2 respectively.

Respondents were made aware that achieving environmental standards and keeping management practices in place would require financial support and that each policy had an associated cost. Respondents were informed that the Expected Annual Cost attribute represented the value that they personally would have to pay per year, obtained through their Income Tax and Value Added Tax contributions, for the rural environmental policy. All of the options were explained to the respondents. They were then asked to consider all three alternatives and to indicate their most preferred option. When making their choice, respondents were asked to consider that rural environmental policy options were restricted only to these three alternatives. Respondents were reminded to take into account whether they thought the rural environmental policies were worth it to them. Following the rehearsal choice set, respondents were faced with a series of at least six choice sets.

Experimental Design

Since different experimental designs can significantly influence the accuracy of WTP estimates (Lusk and Norwood, 2005), it is important to use an experimental design that minimises an efficiency criterion. Given the national scope of this study, and the cost of surveys of this kind, sample size was also an issue. To increase sampling efficiency a sequential experimental design with a Bayesian information structure was employed (Sándor and Wedel, 2001).

A review of recent studies on experimental design (see Ferrini and Scarpa, 2007) reveals that the values in the matrix of attribute levels should

	Option A	**Option B**	**No Action**
Wildlife Habitats	 A Lot of Action	 No Action	 No Action
Rivers and Lakes	 A Lot of Action	 Some Action	 No Action
Hedgerows	 A Lot of Action	 Some Action	 No Action
Pastures	 A Lot of Action	 Some Action	 No Action
Expected Annual Cost	€ 80	€ 20	€ 0

Figure 3.1 Example of a choice set used in choice experiment A

be chosen so as to minimise some expected measure of variance, such as the D_p-optimality criterion:

$$D_p\text{-criterion} = \det\{I(\beta)^{-1}\}^{1/p}, \tag{3.1}$$

where $I(\cdot)$ is the information matrix of the multinomial logit model and p is the number of attributes. A more informative Bayesian measure,

	Option A	**Option B**	**No Action**
Mountain Land	 A Lot of Action	 No Action	 No Action
Stonewalls	 A Lot of Action	 Some Action	 No Action
Farmyard Tidiness	 A Lot of Action	 Some Action	 No Action
Cultural Heritage	 A Lot of Action	 Some Action	 No Action
Expected Annual Cost	€ 80	€ 20	€ 0

Figure 3.2 Example of a choice set used in choice experiment B

the D_b- optimal criterion, suggested in Sándor and Wedel (2001), which is the expected value of the D_p-criterion with respect to its assumed distribution over β or π(β) was adopted with the arrangement of values in the matrix of attribute levels such that:

$$D_b\text{-criterion} = E_\beta[\{\det I(\beta)^{-1}\}^{1/p}] = \int_{\mathbb{R}^p} \{\det I(\beta)^{-1}\}^{1/p}\pi(\beta)d\beta. \quad (3.2)$$

As a prior an informative multivariate normal distribution centred on β was used with a variance-covariance matrix, both of which were derived initially from the first phase of the survey, and subsequently updated at each phase by the pooled dataset from previous phases of sampling using Gauss. This is achieved in practice by simulating the value of this criterion by drawing from the assumed distribution of βs, computing the value of the criterion for each draw, and then averaging it out. The best allocation of values is found by using heuristic algorithms, such as swapping and relabelling (Huber and Zwerina, 1996) and cycling (Sándor and Wedel, 2001):

$$\tilde{D}_b = \frac{1}{R}\sum_{r=1}^{R}\left\{\det I(\beta)^{-1}\right\}^{1/p}, \tag{3.3}$$

where R is the number of draws.

Starting from a conventional main effects fractional factorial in the first phase, a Bayesian design was employed in the second wave of sampling. The design for the final phase incorporated information from the first and second phases. However, not all values of the attributes were allocated in the design by the above approach. The numerical values of cost were assigned on the basis of realism and so as to balance the probabilities of choices across alternatives in the choice set (see Kanninen, 2002). For further information and an evaluation of the efficiency of the sequential experimental design approach used in this study see Campbell (2006), Scarpa *et al*. (forthcoming) and Ferrini and Scarpa (2007).

MIXED LOGIT MODEL SPECIFICATION

Mixed logit models provide a flexible and computationally practical econometric method for any discrete choice model derived from random utility maximisation (McFadden and Train, 2000). The mixed logit model obviates the three limitations of standard logit by allowing for random taste variation, unrestricted substitution patterns and correlation in unobserved factors (Train, 2003). Mixed logit does not exhibit the strong assumptions of independent and identically distributed (*iid*) error terms and its equivalent behavioural association with the independence of irrelevant alternatives (IIA) property.

In mixed logit the stochastic component of utility is portioned additively into two parts (Hensher and Greene, 2003). One part is perhaps correlated over alternatives and heteroskedastic over individuals and alternatives, and another is *iid* over alternatives and individuals:

$$U_{ni} = \beta_n' x_{ni} + [\eta_{ni} + \varepsilon_{ni}], \tag{3.4}$$

where x_{ni} is a vector of observed explanatory variables that relate to alternative i and to individual n; β_n is a vector of parameters of these variables for person n representing the individual's tastes; η_{ni} is a random term with zero mean whose distribution over individuals and alternatives depends in general on underlying parameters and observed data relating to alternative i; and ε_{ni} is a random term with zero mean that is *iid* over alternatives, does not depend on underlying parameters or data, and is normalised to set the scale of utility (Brownstone and Train, 1999). The mixed logit class of models assumes a general distribution for η_{ni}, which can take on a number of distributional forms such as normal, lognormal, or triangular (McFadden and Train, 2000). Denote the density of η_{ni} by $f(\eta_{ni}|\Omega)$ where Ω are the fixed parameters of the distribution. For a given η_{ni}, the conditional probability for alternative i is logit, since the remaining error term is *iid* extreme value:

$$L_{ni}(\beta_n|\eta_{ni}) = \frac{\exp(\beta_n' x_{ni} + \eta_{ni})}{\sum_j \exp(\beta_n' x_{nj} + \eta_{nj})}, \tag{3.5}$$

where L_{ni} is the logit probability. Since η_{ni} is not given, the unconditional choice probability becomes the integral of L_{ni} over all values of η_{ni} weighted by the density of η_{ni}:

$$P_{ni}(\beta_n|\Omega) = \int_{\eta_{ni}} L_{ni}(\beta_n|\eta_{ni})\, f(\eta_{ni}|\Omega)\eta_{ni}. \tag{3.6}$$

Models of this form are called mixed logit since the choice probability is a mixture of logits with $f(\cdot)$ as the mixing distribution (Brownstone and Train, 1999). The probabilities do not exhibit the IIA property and different substitution patterns may be attained by appropriate specification of $f(\cdot)$. While in most applications the mixing distribution $f(\cdot)$ is specified to be continuous, it can also be specified to be discrete, with η_{ni} taking a finite set of distinct values. In this case the mixed logit model becomes the latent class model.

Different types of mixed logit models have been used in empirical work, which differ in the type of structure that is placed on the model, or, more precisely, in the specification of $f(\cdot)$. One approach, as used by Brownstone and Train (1999), is to specify an error components structure that creates correlations among the utilities for different alternatives. The specification employed in this chapter is the random-parameters, or random-coefficients, approach. Random parameters specification of the mixed logit model is also employed in Chapters 4 and 12 of this volume. For further details refer to Revelt and Train (1998), Layton and Brown (2000) and references cited therein.

Individual-Specific Conditional Estimates of Landscape Values

The mixed logit model accommodates the estimation of individual-specific preferences by deriving individuals' conditional distribution based (within sample) on their known choices (that is prior knowledge) (Hensher and Greene, 2003; Scarpa *et al*., 2005). These conditional parameter estimates are strictly same-choice-specific parameters, or the mean of the parameters of the sub-population of individuals who, when faced with the same choice set made the same choices. This is an important distinction since it is not possible to establish, for each individual, his or her unique set of estimates, but rather to identify a mean and standard deviation estimate for the sub-population who made the same choice (Hensher *et al*., 2005). Using Bayes' Rule, the conditional choice probability is:

$$H_{ni}(\beta_n|\Omega) = \frac{L_{ni}(\beta_n)g(\beta_n|\Omega)}{P_{ni}(\beta_n|\Omega)}, \tag{3.7}$$

where $L_{ni}(\beta_n)$ is the likelihood of an individual's choice if he or she had this specific β_n, Ω is the set of parameters in the underlying distribution of β_n, $g(\beta_n|\Omega)$ is the distribution in the population of β_ns, and $P_{ni}(\Omega)$ is the choice probability function defined in open-form as:

$$H_{ni}(\Omega) = \int_{\beta_n} L_{ni}(\beta_n)g(\beta_n|\Omega)\, d\beta_n. \tag{3.8}$$

Bounding of Taste Intensities

A key element of the mixed logit model is the assumption regarding the distribution of each of the random parameters. These can take a number of predefined functional forms, the most popular being normal, lognormal, uniform and triangular (Hensher *et al*., 2005). In most applications, such as Layton and Brown (2000), Revelt and Train (1998) and Train (1998), the random parameters are specified as normal or lognormal. Greene *et al*. (2005) and Greene *et al*. (2006) have used uniform and triangular distributions. However it is well known that choices of some commonly employed mixing distributions imply behaviourally inconsistent WTP values, due to the range of taste values over which the distribution spans. Normal and lognormal distributions are particularly problematic (Train and Weeks, 2005). This is due to the presence of a share of respondents with the 'wrong' sign in the former, and the presence of fat tails in the latter. This is of particular importance in a study concerned with improvements from the status quo, on which taste intensities are expected to be positive. For a general discussion on bounding the range of variation in random utility models see Train and Sonnier (2005), who propose a Bayesian estimation approach; for an application of bounding directly to the expenditure function see Train and Weeks (2005). Following Hensher and Greene (2003), a bounded triangular distribution is used in this chapter, in which the location parameter is constrained to be equal to its scale. Such a constraint forces the distribution to be bounded over a given orthant, the sign of which is the same as the sign of the location parameter (see Hensher *et al*. (2005) for a description of the triangular distribution in this context). In practice, for all random parameters associated with the various categories of rural landscape improvements, it is assumed that $\beta \sim \tau(\theta)$, where θ is both the location and scale parameter of the triangular distribution $\tau(\cdot)$. This includes cost, which is bounded to the negative orthant.

Estimation Procedure

Computation of mixed logit choice probabilities using classical estimation procedures typically requires Monte Carlo integration. The basis of this computation is the generation of pseudo-random sequences that are intended to mimic independent draws from the underlying distribution of the random variable of integration. An alternative approach proposed by Bhat (2001) and Train (1999) replaces these pseudo-random sequences with sequences based on a deterministic Halton sequence. One-dimensional Halton sequences are created using any prime number $p(\geq 2)$. The unit interval [0,1] is divided into p equally-sized segments, and the endpoints or breaks of these segments form the first p numbers in the Halton sequence. Successive numbers in the sequence are generated by further subdividing each segment into p equally-sized segments and adding the breaks in a particular order. The resulting Halton draws thus achieve greater precision and coverage for a given number of draws than pseudo-random draws, since successive Halton draws are negatively correlated and therefore tend to be self-correcting (Train, 2003). Accordingly, many fewer draws are needed to assure reasonably low simulation error in the estimated parameters. In fact both Bhat (2001) and Train (1999) demonstrate that for a mixed logit model, 100 Halton draws provide results that are more accurate than 1000 pseudo-random draws. Overall the application of Halton draws allows a decrease in computation time without sacrificing precision. However while multi-dimensional Halton sequences generally provide better coverage than the corresponding pseudo-random number sequences, problems with high correlation can occur between sequences constructed from higher primes, and thus sequences used in higher dimensions. To ameliorate this, modified procedures such as scrambled and shuffled Halton draws have been used (for example Bhat, 2003; Hess and Polak, 2003). Both these sequences have been found to outperform the standard Halton sequence. As a result, shuffled Halton sequences with 100 draws are used in this chapter to estimate the mixed logit models.

RESULTS AND DISCUSSION

In total, the survey was administered by experienced interviewers to a representative sample of 600 respondents drawn from the Irish adult population in 2003/4. With a further 166 potential respondents refusing to complete the interview, the overall response rate was 78 per cent. During the interview, each respondent completed two choice experiments. For each choice experiment respondents indicated their preferred alternative in a panel of repeated choice contexts, each choice consisting of two experimentally designed alternatives and a status quo (No Action) alternative.

Mixed Logit Models Results

Since this chapter focuses on the distribution of part-worths (WTP values) for individuals in the sample, the results from the multinomial logit models are omitted. Instead, readers are referred to Campbell (2006) for these results. The model of choice for the derivation of individual-specific welfare measures is the mixed logit model. Table 3.3 reports the parameter estimates obtained from choice experiment A. The parameter estimates obtained from choice experiment B are reported in Table 3.4. Both models were produced using NLOGIT (see Greene, 2002). Parameter estimates in both models were generated using 100 shuffled Halton draws. In both models, all the attributes were specified as random, thereby enabling unobserved sources of heterogeneous preferences among respondents to be captured. This was constrained using triangular distributions to ensure non-negative WTP for landscape improvements over the entire range of the distribution. Contrary to Revelt and Train (1998), the mixed logit models were not found to be unstable when all attributes were allowed to vary over the population. The mixed logit model specifications used in this chapter do not include any alternative specific constants effects and do not

Table 3.3 Mixed logit model results for choice experiment A

Attributes	Mean		Standard deviation	
	Beta	**Std error**	**Beta**	**Std error**
Wildlife Habitats: A Lot Of Action	0.842	0.064***	0.842	0.064***
Wildlife Habitats: Some Action	0.610	0.065***	0.610	0.065***
Rivers and Lakes: A Lot Of Action	1.803	0.074***	1.803	0.074***
Rivers and Lakes: Some Action	1.046	0.061***	1.046	0.061***
Hedgerows: A Lot Of Action	0.387	0.059***	0.387	0.059***
Hedgerows: Some Action	0.157	0.059**	0.157	0.059**
Pastures: A Lot Of Action	0.684	0.059***	0.684	0.059***
Pastures: Some Action	0.643	0.063***	0.643	0.063***
Expected Annual Cost	−0.010	0.001***	0.010	0.001***
Log-likelihood	−3373.480			
χ^2	2679.133***			
Pseudo-R^2	0.284			
Bayesian information criterion	6832.124			

Notes:
** Significance at 5 per cent.
*** Significance at 1 per cent.

incorporate any socio-demographic or attitudinal characteristics of the respondents. Instead the mixed logit models reported explain choice between the policy alternatives solely as a function of their attributes. This approach was adopted because the focus of this chapter was to explore the trade-offs between the attributes and, hence, WTP estimates. As noted by Louviere *et al.* (2003), this approach has merits in that it also enables the trade-offs between the attributes to be investigated without complex relationships.

The log-likelihood function at convergence is –3373.480 for choice experiment A and –3775.392 for choice experiment B. Both models are found to be statistically significant, with a χ^2 statistic of 2679.133 and 1901.676 for choice experiments A and B respectively against a χ^2 critical value of 16.919 (with 9 degrees of freedom at alpha equal to 0.05).

Across both models, all estimated coefficients are found to be statistically significant at the 1 per cent level, except for the coefficient associated with Hedgerows at the Some Action level of improvement, which was found to be significant at the 5 per cent level. Importantly, coefficients are also found to have the expected sign. Notice also that the mean and standard deviation coefficients are identical. This is because they were constrained to be

Table 3.4 Mixed logit model results for choice experiment B

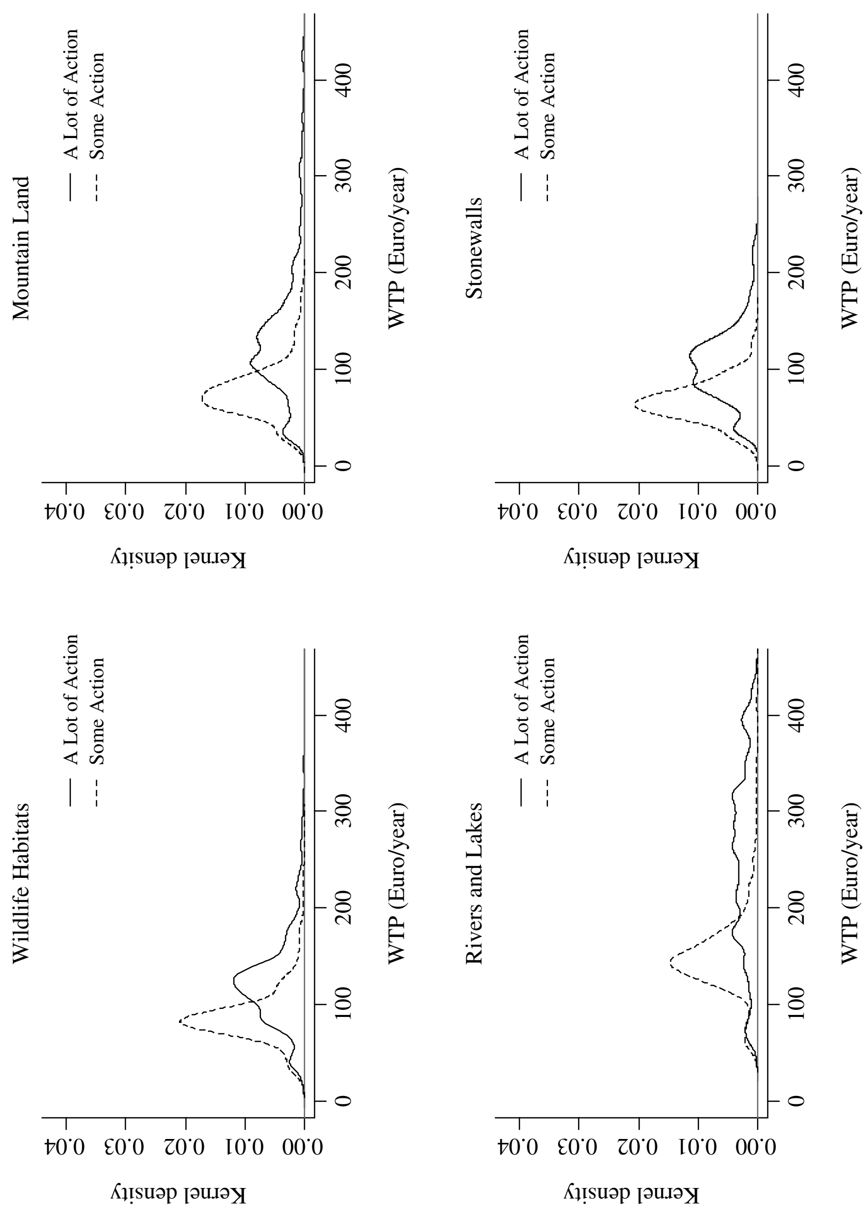
Attributes	**Mean**		**Standard deviation**	
	Beta	**Std error**	**Beta**	**Std error**
Mountain Land: A Lot Of Action	1.041	0.064***	1.041	0.064***
Mountain Land: Some Action	0.598	0.059***	0.598	0.059***
Stonewalls: A Lot Of Action	0.870	0.058***	0.870	0.058***
Stonewalls: Some Action	0.531	0.056***	0.531	0.056***
Farmyard Tidiness: A Lot Of Action	0.794	0.057***	0.794	0.057***
Farmyard Tidiness: Some Action	0.502	0.055***	0.502	0.055***
Cultural Heritage: A Lot Of Action	0.587	0.057***	0.587	0.057***
Cultural Heritage: Some Action	0.577	0.058***	0.577	0.058***
Expected Annual Cost	−0.012	0.001***	0.012	0.001***
Log-likelihood	−3775.392			
χ^2	1901.676***			
Pseudo-R^2	0.201			
Bayesian information criterion	7635.974			

Note: *** Significance at 1 per cent.

equal under a triangular distribution. With the possible exception of the Pastures and Cultural Heritage attributes, the relative dimensions of the estimated coefficients for the landscape attributes at A Lot Of Action vis-à-vis Some Action conform with theoretical expectations of decreasing marginal utility. To illustrate this, the kernel-smoothed distributions of the individual-specific WTP estimates conditional on observed choices (Hensher and Greene, 2003) for each of the landscape attributes are presented in Figure 3.3. From the distributions, it is apparent that for all landscape attributes except for Pastures and Cultural Heritage, the implied monotonicity of the two levels of action is adequately reflected in the magnitude of individual-specific WTP estimates. It is also clear that the attribute most valued is Rivers and Lakes and the attribute least valued is Hedgerows.

Calibration of Landscape Benefits Arising from the REP Scheme

In the choice experiments, respondents were asked to indicate their preferred option on the basis that it would be implemented on all farms throughout Ireland. While this provides WTP estimates for the landscape attributes, it does not reflect WTP for the landscape improvements arising from the REP Scheme. Using 2003 as a reference year – the year in which


Mountain Land
Stonewalls
Wildlife Habitats
Rivers and Lakes
A Lot of Action
Some Action
Kernel density
WTP (Euro/year)
0.00
0.01
0.02
0.03
0.04
0
100
200
300
400

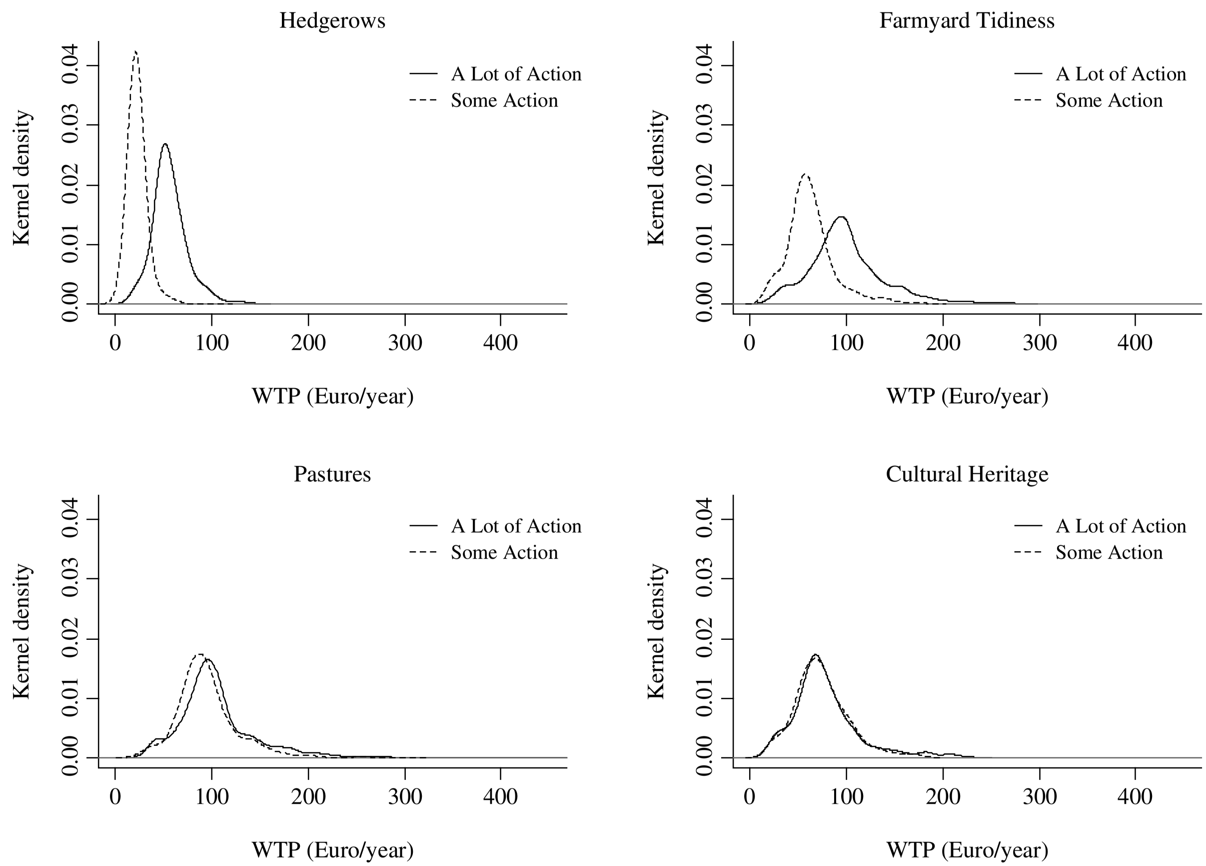
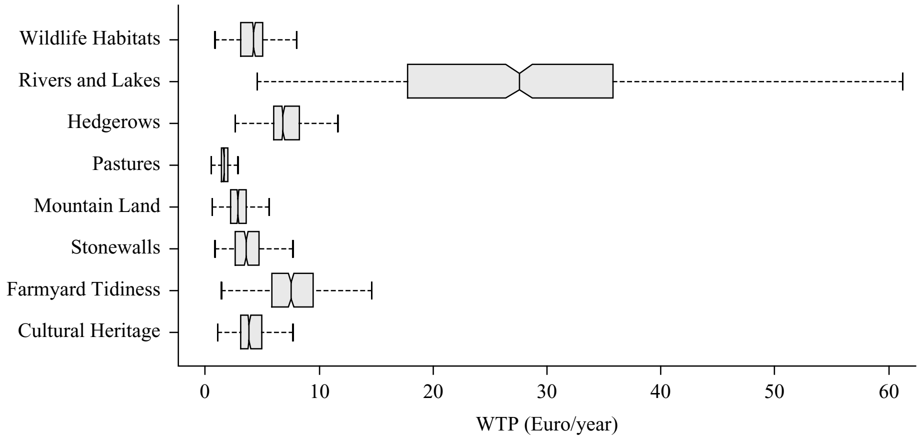


Figure 3.3 WTP distributions for the REP Scheme landscape attributes

the survey fielding began – the individual-specific WTP estimates are thus adjusted to provide realistic estimates for the landscape improvements arising from the REP Scheme. They are first adjusted to take account of the proportion of farms in the REP Scheme – only 27 per cent of all farms were paid under the Scheme in 2003 (DAF, 2004b). Furthermore, because the Mountain Land and Stonewalls attributes are less prevalent on some farms in comparison to attributes found on all farms such as Farmyard Tidiness and water courses (that is Rivers and Lakes) their values were scaled down in accordance with agricultural statistics (CSO, 2000; DAF, 2004a). WTP estimates were further adjusted to take account of baselines and the level of improvement resulting from the implementation of the REP Scheme. Both the baseline and the levels of improvement are defined in terms of the three attribute levels: No Action, Some Action and A Lot of Action. Baselines and levels of improvement resulting from the implementation of the REP Scheme are based on a semi-quantitative assessment of the landscape quality of farms within the Scheme and farms not in the Scheme conducted by O'Leary *et al*. (2004; 2005). As a result, for each landscape attribute WTP is calculated for the improvement under the REP Scheme from: (1) No Action to Some Action, (2) No Action to A Lot Of Action, and (3) Some Action to A Lot Of Action. They are then added to provide an overall WTP estimate for the improvements under the REP Scheme for each of the farm landscape attributes. Boxplots for these are presented in Figure 3.4. From Figure 3.4, it is clear that highest individual-specific WTP estimates for landscape improvement under the REP Scheme are for improvements concerning Rivers and Lakes. Non-overlapping notches also indicate rejection of the null of equal medians. Finally, the individual-specific WTP estimates from each of the landscape attributes are added together to provide an overall individual-specific WTP estimate for the landscape benefits provided under the REP Scheme in 2003. Results from this analysis are depicted in Figure 3.5.

Assessing whether the REP Scheme offers value for money also requires an examination of the costs associated with it. In 2003 the total cost of the REP Scheme was approximately €195 million, combining payments made under the REP Schemes 1 and 2 and administration and inspection costs (see DAF, 2004b). Averaging this cost across the total Irish adult population (aged 15 years and over) (CSO, 2003), enables it to be compared with the overall individual-specific WTP estimates for the landscape benefits provided under the REP Scheme. The average cost of the REP Scheme across the Irish adult population in 2003 was estimated at €63; this is indicated by a vertical line in Figure 3.5.

From Figure 3., it is clear that there is a considerable range in the values that the public are WTP for the landscape benefits provided under the REP



Note: Boxplots – sometimes referred to as box and whisker plots – are a non-parametric method and are graphical devices which can be used to capture a large amount of information. The plot shows the median, 'hinges' corresponding with the first and third quartile of a distribution (that is, the 25th and 75th percentile points in the cumulative distribution) as well as outliers. An observation is classified as an outlier when it is located outside a given multiple of the inter quartile range (that is, the difference in value between the first and third quartile), below or above respectively the value for the first quartile and third quartile. The standard multiple, which is used in the boxplots presented here, is 1.5 times the interquartile range. Notches are also drawn to show the 95 per cent confidence interval of the median.

Figure 3.4 Boxplots of WTP for improvements to the landscape attributes under the REP Scheme

Scheme. It is also apparent that for a sizeable proportion of respondents, WTP for the landscape benefits of the Scheme alone exceeded the average cost of the Scheme across the Irish adult population. Further investigations identified that 256 respondents (41 per cent) had a WTP above the average cost of the Scheme across the Irish adult population and that the individual-specific WTP ranged from 23 per cent to 191 per cent of the average cost of the Scheme.

CONCLUSIONS AND POLICY IMPLICATIONS

Reported in this chapter are the findings from two choice experiments that were carried out to address the value of a number of farm landscape improvement measures within the Rural Environment Protection (REP) Scheme in the Republic of Ireland. The attributes in question were improvement of: Wildlife Habitats, Rivers and Lakes, Hedgerows, Pastures, Mountain Land, Stonewalls, Farmyard Tidiness and Cultural Heritage.

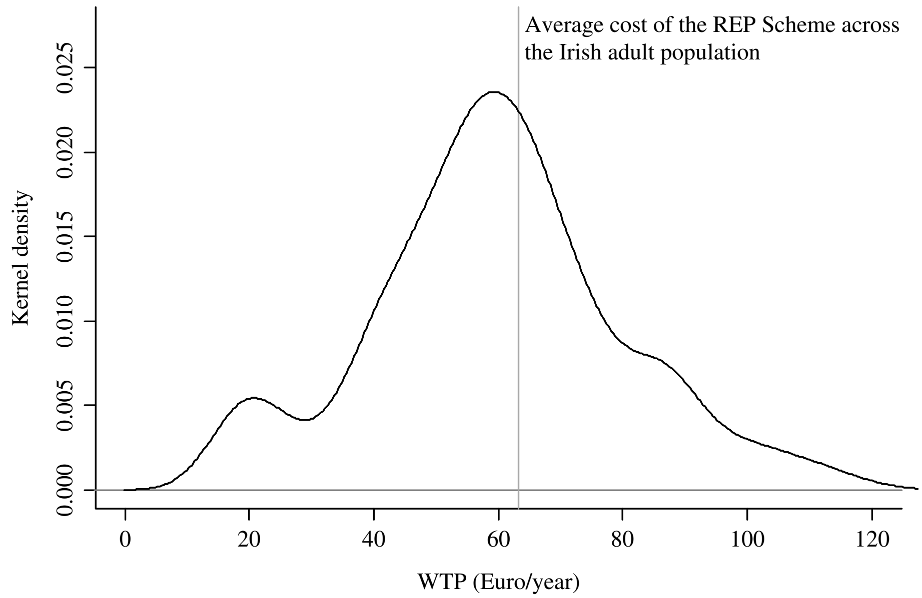


Figure 3.5 Distribution of WTP for landscape improvements under the REP Scheme

Each of these attributes was represented under three different management practices according to the level of action made to conserve and/or enhance it: No Action, Some Action and A Lot Of Action. Since valuation of landscapes are very subjective, and verbal description can be interpreted differently on the basis of individual experience, each level of improvement was qualified and presented to respondents by means of digitally manipulated images of landscapes to represent accurately what is achievable within the policy under valuation.

This study also attempted to take stock of some of the main advances in the areas of multi-attribute stated preference techniques. In particular, following recent results in market research, a sequential experimental design with an informative Bayesian update to improve the efficiency of estimates was implemented. The heterogeneity of the structural parameters of the random utility model was addressed using distributions that bounded the implied WTP estimates. The methodological approach applied in this chapter also enabled the calibrated individual-specific WTP estimates to be directly compared with the average cost of the REP Scheme across the Irish adult population.

There are clear policy uses of the value estimates reported in this study, as they provide a means to evaluate the level of investment in ongoing activities that conserve and/or enhance rural environmental landscapes within the CAP. The results can also be used to inform decisions concerning the allocation of resources for each of the landscape attributes. Based on the results reported in this chapter, the landscape feature to which the public attach the highest value is Rivers and Lakes. Results also revealed that there is a considerable range in the values that the public attach to the landscape improvement measures under the REP Scheme in Ireland, and in many cases they were found to exceed the average cost of the Scheme across the Irish adult population. Aside from the landscape benefits, other important benefits arising from the REP Scheme would include improvements to drinking water, biodiversity, enhanced recreational opportunities, rural development and contributions to farmer's incomes and the broader rural economy. While further research would be necessary to quantify these additional benefits, it is reasonable to assume that, when added to the landscape benefits estimated in this study, the total benefits provided by the REP Scheme are likely to exceed the costs associated with it. On this basis the REP Scheme would seem to be justified.

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